

OF THE
RESULTS RECORDED IN A SERIES OF LECTURES DELIVERED AT
SYDENHAM COLLEGE SCHOOL OF MEDICINE,
ON THE
NATURE, PROGRESS, AND TREATMENT
OF
COMPLICATED INJURIES OF THE EXTREMITIES,
AND ON
AMPUTATION AND ITS EFFECTS
IN
CIVIL AND MILITARY PRACTICE.

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PART I.

Object of the present series of lectures stated.

How endeavoured to be attained. Necessity for care and discrimination in the materials employed. These forming the elements for any judgment upon the questions involved in amputation, and by which they are to be decided. True objects of amputation classed and defined. RESULTS on the system, of those forms of chronic local disease for which amputation is adopted. Results of the injuries of civil life for which amputation is usually performed. Results of the injuries of military life, in like manner treated to the end without operation. Modifications in the results induced by varying conditions, moral and physical. Causes, or diseased actions, which lead to amputation under different circumstances, compared with the causes of death. Causes of variation in the relative proportion of amputations required, and of deaths occurring while cases are under treatment.

I PROPOSE in this concluding lecture to give a summary of the principal results of the inquiry which you have followed, step by step, into the nature, progress, and terminations of the more complicated forms of injuries of the extremities, when submitted to treatment; and, finally, of the results of amputation, when performed at primary, intermediary, or secondary periods, by different operative methods, and under different influences, physical and dynamic. I purpose to bring before you at the same time, in a condensed form, the principles of practice these results are calculated to establish, and the legitimate bearing of the facts upon some of the leading doctrines of the present day in relation to amputation, its relative expediency and efficacy at different periods, and the treatment of grave and complicated injuries of the extremities.

In commencing this series of lectures, I

proposed to myself an object certainly not hitherto attained. I believe that you will find an inquiry, such as we have been engaged in, similar in aim and scope, and carried out in all its details, had not previously been attempted. But if I thus seem to claim any merit for the attempt, I beg you to believe that my labours were undertaken with no feeling of overweening confidence, but with a full consciousness of all the difficulties of my task. I have been impelled chiefly by a strong conviction of the importance and scientific interest attached to the subject. And on this ground have I ventured to engage at such length your attention. I must beg you also to believe that I recall the circumstances at this moment, conscious that my best efforts in this almost untrodden path have fallen far short of my wishes, and of the exigency of the subject. Yet the opportunities I have had of studying the effects of injuries and operations have been unusual, and seemed to justify the attempt.

Many years a principal medical officer in two services, during which I was entrusted alike with the duties of the field in every action, and with the organisation and direction of all the hospitals required for the sick and the wounded of the auxiliary forces engaged, it was not less a pleasure than an imperative duty, to devote every hour not actually spent in the field, or on the line of march, to the study and treatment of the cases, medical and surgical, filling large hospitals, and for the efficient care of which I was justly held responsible. Perhaps I am indebted to the flattering confidence which entrusted me with such heavy and responsible duties at an earlier period of my professional life, than in ordinary circumstances is usual, not only for enlarged opportunities of studying disease and injury in all its aspects, but for that zest and devotion to the labour it entailed, which I always felt and believed to be the only adequate return I could make.

Under these circumstances, at first insensibly, and later, as the result of continued efforts directed to that end, I found materials accumulate of the most valuable kind, consisting of records of cases, experiments, and observations, and of preparations of morbid structures, which, in their number and varied nature, might seem surprising, collected as they were in the course of the most arduous services, during the late civil wars of the Peninsula; unless it were stated, as it is my pride at all times to acknowledge, that it was my peculiar fortune in these duties and labours to be aided and seconded by a most zealous and indefatigable medical staff.

To Mr. Gannon and Mr. Blair, in Portugal; to the former also in Spain; and to Drs. Johnstone and Dolce; to Messrs. Sholl, Dorset, and A'Beckett, Staff-surgeons in the Force, and to the Medical Officers generally, I should be ungrateful, indeed, if I alluded to the collected scientific results obtained from the numerous hospitals of the two services (and be supposed to claim any merit from them), if I did not, even at the cost of a digression like the present, give them back the ample share which is so justly their due. The results and the facts, embodied in these and other lectures delivered here, were collected under my directions, and placed in my keeping, only by their efforts united to my own. I consider them held in trust, therefore, not to be used for my own exclusive benefit, nor without due acknowledgment.

One of the peculiar difficulties I have felt throughout these lectures, I explained to you in my last, viz., that I had felt compelled to lead you through the *steps of the inquiry*, and to furnish the *materials* for the investigation, since I could not refer you to any already existing, instead of confining myself, as I should otherwise have done, to *results* only. My object in this concluding lecture, therefore, is to separate from the mere process of inquiry the *results* actually obtained, and present them to you as unencumbered by details as the nature of the subject will permit, and in a clear and lucid order.

The object of the inquiry through which I have conducted you in these lectures, was to ascertain and determine what were the *effects of amputation upon the system*, uncomplicated by disease or injury, and the *true causes of mortality*; the *effects of amputation when the operation was superadded to the forms of pre-existing disease, or injury*, for which it is most usually performed; and, lastly, what were the *circumstances and conditions* moral, dynamic, and physical, which determined the *relative degrees of mortality or success* found to mark the operation in practice.

If the object were attainable, it is obvious that in proportion to the certainty and precision with which these bases were fixed, would be the accuracy with which we could predict the result of amputations, according

to the predominant conditions and influences, and determine the safest practice to be pursued, whether the surgeon should rely upon treatment or resort to amputation; and if the latter, at what period in what mode, and under what conditions, the operation could most successfully be performed.

That by any means a power could be obtained of determining with perfect certainty, in each *individual case*, that any given result would follow a given course pursued by the surgeons in reference to it, is not to be imagined. Such fixed results, however, attainable in the mass, are clearly beyond our reach, in the individual or in any fractional portion, except when our materials are formed of inert matter, subject to no variation in the laws by which each part and the whole are governed. Each part of the mass, that is, each individual of the human species presents, on the contrary, an infinite variety of conditions and powers of resisting, of reacting upon, and of modifying the influences to which they are subjected. A law that will produce an unerring and unvarying result upon a thousand, would in that number produce an almost infinite variety of results if the individual parts were each analysed.

It is thus evident that we cannot determine a rule of practice, or a principle of medicine applicable to the whole, by the observation of individual cases, and deductions from one or two of these must not be relied upon, for they lead to the most contradictory, vacillating, and erroneous conclusions. This only can be obtained by combining the observation and the records of a large number, arranging them according to predominating influences, and analysing the results thus ascertained. The first classification must be founded upon the largest and broadest characters, and gradually in the spirit of analysis, subdivided in reference to the minor characteristics and differences down to the last link, comprising the details of an individual part. A true principle can only thus be legitimately developed, or with certainty determined—not liable to change, because fixed on a basis of facts, sufficiently large to give it solidity—not liable to be upheld one day and subverted the next by the breath of a bold assertion, because a superstructure thus raised can only be successfully assailed by a doctrine equally largely based, all its parts inviting and bearing the test of scrutiny and analysis.

Principles, then, let me repeat, are calculated to give certainty to the practice of medicine *applied to the mass*; no stretch or power of human intellect can determine with equal certainty the *results of individual cases*. By applying and testing principles by their effects on the mass, we gain the same relative power conferred by a microscope; everything, to the minutest action and effect, is enlarged in its proportions to such a vast degree, that we can appreciate the smallest

resemblance and differences, thus rendered gross and palpable. Statistics may better be illustrated by reference to the manipulations of a scientific chemist, ten thousand fractional parts aggregated into one, gives a mass sufficiently large to produce appreciable and definite results in the crucible, each of which, from their larger proportions, can be submitted to various tests, until their real nature is determined with precision and with the utmost certainty: whereas the same process by no art can be successfully applied to an unit, or a grain's weight, still less can any intermediary result be tested and analysed in various ways, under different conditions and influences, until a conviction of truth and accuracy in one fixed product is obtained.

In this spirit, upon these grounds and on this principle, should statistics be applied to medicine; and thus applied and understood, they form a means of advancing science, yielding in none, hitherto applied in efficiency, value, and importance. Neither certainly can they boast of any exemption from labour: they are not to be approached carelessly, or to be taken up by snatches, and again laid down. To elaborate a series of conclusions on which general principles may be constructed, requires long and patient efforts to collect facts, which form the minute particles to be aggregated. To form a sufficient mass for the crucible, they must be faithfully observed and discriminated, otherwise fragments of different materials are added to the matter to be tested, and falsify the whole of the results. The facts are, so many grains of gold, each requiring the same care and discrimination in its collection and elimination from all earthy or extraneous matter in connection, which may often bear some analogy, and yet be essentially different in character and properties. When these separate parts or particles, by a continued series of efforts, amount in the aggregate to a sufficient mass to admit of analysis, the results must be submitted to various tests, by modifying the circumstances, by the combination of various other elements, &c. This process in itself is one requiring the utmost care and conscientiousness, otherwise, however carefully selected may have been the materials, the results may be full of error.

I have here given you a description of my own task, and of the various steps of the inquiry we have prosecuted together; the conclusions I have laid before you were none of them foregone: I placed the materials I had been years in collecting into the crucible before you, analysed them even to their last elements, and then declared to you the legitimate results. To thus submit materials to this process, it was imperative that I should myself have collected them, not that others might not have performed this part better and more amply, but that no such facts, in complete series, with all their va-

rious characters and conditions, essential to their classification and analysis, existed in the records of surgery, without the aid of which I must necessarily have abandoned the enterprise.

I might, however, have given you, like the scientific chemist, the mere results in the last combination and the most concentrated form. My first idea was to do this, shrinking from the possibility of wearying with a detail of the whole of the processes by which they were elaborated, and the tests and materials employed. But when the chemist wishes to introduce any new combination of elements, from which he derives a result differing in some properties from any others previously admitted in the laboratory, he feels it is not sufficient to state the fact that he has obtained a result, but he details the elements employed, the analysis by which he proves them to be those, and no others; the combinations they assumed, and the various tests to which he subjected them, and under what conditions of temperature or external relations, generally, such tests were applied; that all might judge, and not he alone, whether these were capable of bringing new influences to bear, not contemplated by the manipulator, and consequently giving admission to sources of fallacy in the results. Moreover, if the whole process be delicate, complicated, highly susceptible of sources of fallacy, requiring an aggregate mass of material difficult for any single individual to collect, before the result can be fully established, and take its place among the fixed products, it is highly desirable that it should be made public, that it may be elaborated by others elsewhere, with the united aid of many, to produce a mass of evidence sufficiently large to inspire confidence, and indeed a certain conviction of the accuracy of any result obtained, from such an aggregate of material, by competent inquirers.

Influenced by these considerations, I have gone through the whole of the process with the mass in my hands, not so large as I could wish, but collected and sifted with great care. If any one doubt the accuracy of the results, the competency of the processes, or of the amount of the mass subjected to the crucible, and all are open to discussion, I shall hail with great pleasure the efforts of others to attain the same end I have in view. I shall rejoice in those efforts, assured that truth will be obtained, and that fixed principles of practice, in reference to the more important operations of surgery, will supply the place of loose conclusions, based upon erroneous premises; and that the present rules of practice which, whether they may prove right or wrong, are at all events founded upon imperfect analogies; general impressions of imperfectly-recorded and often contradictory experience; and numerical results, either too small in number, or when large, without the necessary guaran-

tees of their completeness and accuracy, to warrant the development of a general principle.

Amputation involves many questions of the highest importance; to decide any one of which certain materials are required to form the elements of judgment; elements not to be acquired by reference to the result of cases of amputation merely. To determine the advantages or expediency of amputation, under various conditions, we must be able to compare its effects with those arising from local disease, and from the forms of injury which usually require amputation, treated under similar conditions; and from those arising from amputation simply, where no pre-existing disease or injury existed, yet performed under a certain similarity of relation and condition. We can only thus, by the knowledge of the separate effects of each, attain the power in complicated conditions and injuries, to anticipate in some instances, and in others to appreciate the combined effects, and to understand their relation to each other, and the causes put in action.

Unvarying precision and entire certainty can rarely, if ever, be attained in medicine, where subtle vital powers form a part of the materials, as it were, on which we are to reason. But in determining and anticipating the progress of disease, how much have we attained, within the last century, that before seemed impossible! How, surely, may we rely upon the truth of certain general rules and bases of prognosis; not always in individual cases, but fully on any large number. As we see in all nature's schemes the perfect similarity of means adopted, under similar circumstances, to produce similar effects, we are warranted in assuming that in the human body, if we can with precision define similarity of circumstance, and of means (in the form of morbid actions which take place), we may also certainly define from these data the end or effect which will result.

In reference to the results of injuries of the extremities and of amputation, the attempt to obtain this power has scarcely hitherto been made; and the present effort, recorded in all its steps in these lectures, imperfect in many of its parts, from the impossibility of the experience of any one individual, how large soever his field of observation, supplying all the wide range of facts required in sufficient number, has at least sufficed, I trust, to convince you that the object in view is fully attainable—that it only requires the *correct and complete records*, during a few years, of some of the chief hospitals, military and civil, in this and other countries, in relation to the cases usually requiring amputation in civil and military life, to furnish the desideratum.

The results, and, so far as possible, results only, which I now propose to recapitulate, and in as simple a form as may be attainable with perspicuity, in treating of a subject branching necessarily into a number of secon-

dary, but not the less important parts or subdivisions, may be classified in reference to the purposes for which amputation is employed.

Surgeons resort to amputation with many different objects in view—thus to be defined.

Classification of Objects to be attained by Amputation.

1. To remove a limb, useless from original malformation, or from contractions or deformity induced by disease or injury of remote occurrence, such disease or injury having left no trace in the system or health of the patient. To remove, in other words, a limb which produces inconvenience in a locomotive sense, but is not calculated to give rise to disturbance or deterioration of health, how long soever the limb may be permitted to remain. This forms the smallest class—amputations without the contemporaneous existence of disease or injury to modify the effects of the operation upon the system, and may be called *Amputation for Deformity*.

2. To remove a limb which, from local disease of a part, or the whole of its textures, leaves no rational ground of hope that the limb will ever be restored to health and vigour, or be made useful to the patient, however long permitted to remain; while the continuance of the disease, on the other hand, for an indefinite period, is calculated seriously to disturb the system, deteriorate the health, and ultimately endanger and shorten the life of the patient — *Amputation for Chronic Disease*.

3. To remove a limb at once, when so severely injured as either to be clearly incurable, or so likely, by its effects on the limb and the system, to destroy life before any hope can be entertained of completing the reparative process, that the attempt is not deemed justifiable; thus anticipating any effects depending on the progress of diseased actions in the shattered limb, and their influence on the system, constituting the class of *Primary amputations*.

4. To remove a limb during the first twenty days of treatment, which has been severely injured—not to anticipate the first effects, which have, on the contrary, been allowed to supervene, but to avert the ultimate result of those effects when they threaten to be fatal, or have so far added to the local injury, as to leave no hope of a more favourable period for amputation, or the possibility of cure, if longer retained. These supervening actions are often of specific and well-defined character, such as secondary hæmorrhage, gangrene, partial disorganisation from excessive suppuration, &c. And inasmuch as the operation is performed in the intermediate period between the non-supervention of febrile action and its subsidence, usually shortly after the full establishment of the suppurative processes, these cases may be denominated *Intermediary amputations*.

5. To remove a limb which, from the effects of an injury while under process of treatment (and after the febrile action first induced has subsided), is shown to be incurable—certain to prove useless, even if union take place; and if longer allowed to remain, to involve the system generally in disease, leading to a fatal result. These constitute *Secondary amputations*, properly understood and defined, and exclusive of the *Intermediary*, defined in the last class.

These five classes of cases, supplying causes for amputation, evidently comprise, each in their outline, many sources of influence upon the *progress* and *result* of the operation.

In the first class, indeed, we must evidently look for the *effects of the operation* pure and unmixed upon the system, exposed only to such influences as act upon the subject before operation; and upon all not amputated, and treated in the same locality. Here we test the influence of amputation, and test the effects of *different modes of amputation and of site*, whether performed on the upper or the lower extremity.

The second class gives the effects of the operation, in combination with the effects of a local disease, upon the system, in the majority of long continuance.

The third, fourth, and fifth, give the effects of the operation superadded to the previous shock, more or less recent; and in the fourth and fifth, in addition, the effects of local diseased actions. The effects of the operation are thus complicated by the effects of the injury, according to the period elapsing from its infliction.

To anticipate the result of the most complicated combinations, we must be well acquainted with each separate class of effects. Hence the necessity of an inquiry into the effects of chronic and local diseased actions of the extremities upon the system: the same of the injuries of different nature, extent, and degree, and in different sites treated under different conditions of external circumstances. This inquiry concludes the **FIRST PART** of the subject.

The **SECOND PART** leads us to the effects of amputation, *per se*, on a healthy frame, and to the effects of the operation when superadded to a long-continued chronic local disease. These classes of results afford us the means of determining the relation between the effects and results of amputation, in those cases where amputation is performed for injuries, at three different periods from the receipt of the wound, and when the two (effects of injury and of amputation) are consequently in combination. The results of each singly may be compared with the results of both combined. This forms the true subject of the *second part*. The first part you will find comprised in the first ten lectures: the second in the remaining nine.

Effects of Chronic and Local Diseased Actions of the Extremities upon the System.

The diseased actions usually leading to amputation, are those only which interest us especially; but these are various. Diseased joints, the majority scrofulous, form by far the largest proportion. Caries, necrosis, tumours, gangrene, ulcers, are the chief forms in the remainder.

Dr. Hayward gives an account of all the diseases for which amputation was performed subsequent to the opening of the Massachusetts Hospital. These amputations amounted to 47 on 45 patients.

	Died.
20 for diseases of joints.....	3
15 ulcers	1
4 frost-bite.....	0
3 abscess and fungus.....	1
2 fungus hæmatodes	0
2 tumours	1
1 deformity	0
—	—
47	6

Mortality 1 in 7.8.

Only 5 of this number were of the upper extremity; and 2 of these were diseased joints.

In Dr. Lawrie's record of amputations for disease in the Glasgow Infirmary, the numbers amounted to 153; and 98 were performed for diseased joints; 26 for caries and ulcers; necrosis and tumours, 12 each; gangrene, 5. 1 in 5 of the diseased joints amputated were of the upper extremity, although still more than half of the whole number were of the *knee*.

Dr. Norris reports from the Pennsylvania Hospital, that in 23, the total cases amputated for disease in a given period, only 5 were of the upper extremity. The mortality in the lower extremity, 1 in 4.5; in 5 of the upper, none.

Of the final results of any number of these cases of local disease *treated without amputation, the proportionate mortality, or the causes of death*, there is no statistical record, so far as I know, to enable us to draw any very positive conclusions. Speaking from general experience, however, I have little hesitation in saying, that the more usual terminations of diseased joints, ulcers, caries, and necrosis, is hectic fever, occasionally accompanied by disease of the viscera, of the lungs more especially, and the mucous membranes of the intestines. Gangrene, malignant tumours, and fungus hæmatodes terminate somewhat differently: if spontaneous gangrene, the fever developed is very generally typhoid, the patient passing rapidly from delirium to a state of coma. With malignant diseases and tumours, the same form of morbid action is frequently developed in some distant part, often involving, directly or indirectly, some important viscus: at other times, the patient sinks, with hectic or irritative fever,

worn out at last with the incessant drain and irritation kept up, exhausting all the powers of life.

As the cases for which amputation is recommended are always deemed incurable, we may consider that all, sooner or later, lead to death by these diseased actions, if life be not cut short by the more sudden appearance of some fatal and irregular action.

Thus much for the effects on the system of the local diseases for which amputation is usually performed. We may safely conclude that the diseased actions do not kill rapidly; patients linger for years, living for half a lifetime with ulcers, tumours, and even diseased joints and caries; yet all that are incurable ultimately hasten, and not only indirectly, but often in a direct manner, the death of the patient.

Effects upon the System of Complicated Injuries of the Extremities occurring in Civil and Military Life.

Leaving the class of chronic diseases of the extremities, and their effects upon the system where any actions set up are in the majority of cases characterised by little intensity, and kill rather by the gradual exhaustion of the system from long-continued waste and irritation, than by the development of sudden and fatal supervening diseases during treatment. What did we find the effects of severe injuries of the extremities fracturing the bones, crushing and lacerating the soft parts, to be, when they are treated without the intervention of amputation? What is the proportionate mortality, and what the causes of death?

Cases of injury in their progress present a vivid contrast to the cases of chronic disease. As the morbid state in injuries is sudden in its supervention and violent in its characters, so are the diseased effects resulting neither mitigated in form nor slow to destroy: that an injury to the extremities is more dangerous than a chronic disease, becomes the first and inevitable inference. Whatever dangers amputation may bring, we are thus informed, therefore, that *they are superadded to a class of cases often rapidly fatal without its aid or intervention.* In diseases requiring amputation, the site or nature of those actions is of comparatively little importance—not so in injuries. Many circumstances and conditions require consideration in determining the effects upon the system of injuries, which exercise but an obscure or trifling influence on the progress and results of cases of disease.

Different classes of injuries give different results. There is a difference to be observed even between the injuries of civil and of military life, where fracture of bone and laceration of soft parts may alike be the chief features of the case. Our statistics on the result of injuries in civil hospitals are very imperfect; the two American hospitals to which I have alluded, and the Glasgow Infirmary, alone afford any

collected data to which I can refer, and these are far from being as complete as could be desired.

In reference to the results of treatment without amputation adopted for injuries of civil life, I am only able to refer you to Dr. Lawrie's paper singly among the records of surgery, for a few data in a collected form.

In 40 compound fractures and dislocations treated and not amputated, 17 died; giving a mortality of 1 in 2.3 in the lower extremity, and of 1 in 2.2 in the upper. The diseased actions supervening and causing death is not stated.

It is remarkable that in this series the upper extremity gives a mortality even greater than the lower.

In reference to the injuries of military life, chiefly gunshot, the largest number recorded showing the *mortality* of injuries of military life (where one or more bones of the extremities are broken with laceration of soft parts), we owe to the conviction of the fatal results of amputation entertained by the surgeon-general of the Prussian army in 1762, M. Bilguer. In 816 gunshot fractures of the extremities received into the hospital under his direction at one time, in no single instance was amputation permitted.

Of this series (in round numbers) *one-half* died; *one-fourth* lived, retaining crippled and useless limbs: *one-fourth* alone were returned cured, able to do duty in person, or to work at any trade.

Of the diseased actions causing death, nothing is said. This deficiency, however, in the preceding lectures, I have supplied by the results of another series of cases treated in hospitals under my own direction.

In reference to the mortality and disability resulting in this series consisting of 235 cases, including 55 partial fractures of the bones of the extremities, you have seen that 82 were amputated.

38 of which were followed by death.

38 of the remainder died under treatment.

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The mortality was 1 in 3—one-third.

And more than half of these cases of death without amputation were induced by vital actions, disturbed, impaired, and finally arrested *without organic disease or lesion of structure*; the remainder with affections of viscera, often purulent depôts, and various accidental or irregular actions, such as secondary hæmorrhage, gangrene of limb, &c.

115 recovered with useful limbs—say one-half.

44, or somewhat more than one-fifth, recovered, but crippled by the removal of a limb.

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Thus the united *favourable result*, as regards the question of *life*, is the recovery of 1 in

1.48, or two-thirds of the whole number, including the results of amputation.

The united *unfavourable* result, considering the loss of life or of limb as both unfavourable, the latter closely corresponding with M. Bilguer's *invalids*, will be 120 cases in 235, or 1 in 1.9—say *one-half*.

If *partial* fractures, however, be excluded, and those injuries which only secondarily involve the integrity of the articulations (both less fatal classes of injuries), and in the 235 amounting to 55, we find 1 in 1.5 was the combined unfavourable result of the gravest character of injuries, or two thirds; 1 in 2.4 losing their lives between one-half and one-third, and 1 in 4.2 their limbs only; a fourth, therefore, crippled. Still the mortality is considerably less than one-half; and the fourth crippled are free from the permanently diseased state of a shattered limb, which remains not only useless in a locomotive sense, but hurtful to the patient's health.

Thus, in reference to Bilguer's experiment, the worst result where amputation was performed in a large proportion of the worst cases, and many performed under most unfavourable circumstances, is *a considerable saving of life*; and no greater proportion of "maimed" results, all are in a *better* state by the removal of the limbs, than if they had been allowed to retain them, and survived; while one-third instead of one-fourth are returned cured to their occupations. I have taken here, I believe, as unfavourable a series as well could be selected to compare with Bilguer's series; the result, therefore, is the more conclusive and striking. If the 34 cases of death under treatment had been amputated at an early period, at a very low average, more than one-half would have been saved, thus adding from 18 to 20 to the 42 saved with loss of limb, reducing the actual loss of life from 73 to 53, or 1 in 3.4, between *one-third* and *one-fourth*; the maimed without disease to 62, or 1 in 2.7, between *one-half* and *one-third*. The cured retaining useful limbs remaining as before, *one-third*.

If the cases treated in one of the hospitals under my charge during a period of thirteen months (the series comprising complete fractures with lacerated wounds, and nearly one-third of which were injuries involving large articulations), to the exclusion of partial fractures and cases where the joints were only secondarily involved, be analysed (see Tables I. and II.), it will be found that 100 cases remained and were treated to the end after the whole series of 180 had been weeded, as it were, by 43 primary amputations, and 37 (generally of the worst cases) had also been eliminated from the 137 at first submitted to treatment by secondary, or at least subsequent amputations, 34 still died of the 100, giving a mortality of 1 in 3.

This seems to be as favourable a view, therefore, as can be taken of the result of these injuries when treated; and if amputa-

tion be not resorted to, rarely less than half will perish, and while from *a third* to *a fourth* may be cured and retain useful limbs, the remainder with *useless and crippled limbs* and shattered health will be left to drag on a very painful residue of life; the maimed limb, unlike a healthy stump, proving a pregnant source of future disease and discomfort.

In conclusion, then, it seems by such evidence as can be obtained, that the mortality of complicated injuries of the extremities, whether in civil or military life, if treated, is rarely likely to be less than one-half, when upper and lower extremities are in about equal proportion, and not more than one-third are joint cases. In addition to this, a considerable number preserve only shattered and useless limbs; the loss of useful limb and of life taken together, cannot be estimated at less than two-thirds of the whole number treated. If the average were applied to the upper extremity alone, the deaths would probably be 1 in 7 or 8 only; but if to the lower, as much as 1 in 1.7; and thus varying, according to the modifying conditions already applied, to the series of 100 cases.

The result of not amputating is to alter the proportion of dead to the crippled, increasing the former, and by the same number diminishing the latter; in addition to which the maimed are left more or less suffering for life by the limb retained, in addition to the total loss of the use of the limb.

Are we to conclude from these large results that it is always expedient to amputate, and that an advantage as clear and evident will always result over the practice of treating such injuries? May we venture to state the positive advantage gained, under all circumstances, to be as stated above?

The preceding lectures must have amply proved how full of sources of fallacy are such broadly-stated statistical results, and how vain is any reliance on their undeviating accuracy. These results, you are already aware, therefore, are *true only as regards certain conditions and proportions*. Change any one of these, and the results are changed! To arrive at a close approximation to truth, and to correct averages applicable to any series of cases, we must know, and be in a position to determine, what is the mortality and what the diseased actions causing death in cases of fracture under various conditions and proportions to each other and the whole; and be enabled to compare these analysed or isolated results with the mortality and diseased actions supervening in amputations under similar circumstances, before we can solve any of the questions connected with the operation, its comparative mortality and expediency.

Several lectures were devoted to demonstrate to you how infinitely any general average of mortality varies, and what the different rates were, according,—

First. To the *site of injury*, whether involving upper or lower extremity.

Secondly. To the *nature of the injury*, its *degree* and *extent*.

Thirdly. To the nature of the *external circumstances* prevailing during the treatment of the case.

Reference to the analysis already given of this 100 cases, will show that the average, if all the cases were under any one of the conditions just stated, would be completely changed. Thus it is the correct average on 100 cases, and probably would not vary much in any other 100 where similar proportions exist of injuries of upper and lower ex-

tremity; of joint cases, and of fractures merely; of favourable or unfavourable cases for treatment, and treated under similar circumstances. Until surgeons will thus classify their cases, no correct average can be stated: that which is correct of one combination of these leading distinctions, is utterly incorrect if applied to another, and a different classification.

A glance at this summary of results, classed after strict analysis in reference to the predominance of these three leading circumstances or conditions, show, in the most obvious manner, the idleness of any attempt to establish averages except in relation to them.

			UPPER EXTREMITY.			LOWER EXTREMITY.		
No. of Cases.	Deaths.	Mortality.	No. of Cases.	Deaths.	Proportion.	No. of Cases.	Deaths.	Proportion.
30 injuries to joints with fracture	18	1 in 1.6	13	3	1 in 4.3	17	15	1 in 1.1
70 compound fractures not involving joints	16	— 4.3	39	4	— 9.7	31	12	— 2.5
100	34	1 in 2.9	52	7	— 7.4	48	27	— 1.7

These few figures express and embody very important results. The mortality in 100 cases of complicated injuries of the extremities, according to the usual mode of stating it, is 1 in 2.9, or say *one-third* of the whole number treated. You cannot doubt after this evidence that such an average, although strictly correct as regards the series in question, is yet entirely subject to a variety of conditions and proportions; and that if these are altered, the average on the mass is totally inapplicable and incorrect.

This fact has been enforced and demonstrated in several lectures; let us take a review of some of the chief results and their bearing upon this part of our subject.

If the cases treated were all wounds involving joints of the same relative number of upper and lower extremity, and treated under the same circumstances, the proportionate mortality would be..... 1 in 1.4

If all were fractures in the same manner with the single difference of not involving joints..... 1 in 4.4

Instead of *two-thirds*, less than *one-fourth* perish. Again:—

If all the injuries were of the upper extremity, similar in their degree and other circumstances (one-

third being of joints), the mortality would be 1 in 7.7

If all of the lower extremity (one-half joint cases) 1 in 1.7

If, on the other hand, all were injuries of joints in the upper extremity 1 in 4.3

If all were fractures without injury to joints 1 in 9.7

If all were of the lower extremity and injuries of joints 1 in 1.1

If all were fractures without injury to joints 1 in 2.4

Nothing can be more palpable, striking, or obvious, than the modifications in the results induced by site, and this one distinction in the nature of wounds, viz., whether implicating an articulation or not.

But it has also been demonstrated to you, that if a series of cases were treated under favourable circumstances or under unfavourable circumstances, or a series of favourable cases for treatment, and a series of doubtful and again of unfavourable cases were submitted to treatment, every one of these conditions would produce a no less striking difference in the average number of deaths. A summary of the results brought forward in preceding lectures and in detail, in reference to these conditions, can leave no room for doubt.

	Site.	No. of Cases.	Deaths.	Mortality.	Total Mortality.
INJURIES INVOLVING JOINTS, doubtful or unfavourable cases for treatment— <i>external circumstances favourable</i>	Upper ex- tremity	6	1	1 in 6.	2.2
	Lower ditto	5	4	— 1.2	
COMPOUND FRACTURES NOT INVOLVING JOINTS—similar injuries to the above, with this distinction only, and treated under similar circumstances	Upper ex- tremity	2	2*	— 1.	3.0
	Lower ditto	4	0	0 in 4	
JOINT CASES—similar character, but treated under <i>unfavourable circumstances</i>	Upper ex- tremity	7	2	— 3.5	1.4
	Lower ditto	12	11	— 1.0	
Fractures—ditto.....	Upper ex- tremity	6	2	— 3.0	1.5
	Lower ditto	12	10	— 1.2	
COMPOUND FRACTURES — favourable cases † treated under <i>favourable circumstances</i>	Upper ex- tremity	16	0	0 in 16	0 in 18
	Lower ditto	2	—	0 in 2	
Similar class of cases treated under <i>unfavourable circumstances</i>	Upper ex- tremity	17	0	0 in 17	14.
	Lower ditto	11	2	1 in 5.5	
		100	34	Up. extremity 1 in 7.7 Lower ditto 1 in 1.7	1 in 2.9

This summary shows at a glance that these important conditions, viz., the nature of the wound, the site, and the external circumstances under which the cases are treated, exercise a decided influence; it also furnishes the means of determining the proportionate amount of influence of each of these conditions upon the mortality. We are warranted, therefore, in the following conclusions:—

In reference to the Influence exercised by the Nature of the Injury and the External Circumstances.

First. Injuries directly implicating any of

* Both with complicating wounds of chest.

† Under the denomination of *favourable cases for treatment*, none of the compound fractures of the *femur* are included, such cases never being *favourable*; and so of lacerated wounds into joints with fracture of bones. The *favourable cases*, therefore, are exclusive of fractures involving joints, and of compound fractures of *FEMUR*, the two most fatal classes of injury.

the large articulations, from the ankle and

wrist upwards, are all more or less doubtful, and often decidedly unfavourable, cases for treatment: lacerated wounds into joints attended with partial or complete fractures, can only be compared with fractures of the worst kind; and even thus classed, and when both are treated under similarly *favourable* circumstances, the mortality in the former class is largely increased, especially in the lower extremity, when the deaths in cases of joint injuries is nearly quadruple that occurring from fractures simply. In the upper extremity the present series does not afford any fair criterion; but I have always found in doubtful cases that the mere fact of an articulating surface being implicated was sufficient to turn the balance unfavourably.

Secondly. This difference between the results of fractures implicating, and the more grave cases of fractures not implicating joints, so palpable and evident when both are treated under *favourable* circumstances, is almost lost when both classes are treated under *unfavourable* circumstances. Notwithstanding the mortality in the class of injuries to

joints is increased nearly one-half in the upper extremity, and in a lesser degree in the lower, yet the mortality in bad cases of fracture is increased in a so much larger proportion, that the difference between the results of the two classes of cases in the aggregate is only a minute fraction, the mortality being as 1 in 1.4 to 1 in 1.5. The proportions in the upper and lower extremity maintain about the same relative rate in both classes; injuries of joints in lower extremity being slightly more fatal.

In cases of injury of joints the upper

extremity gives a mortality of .. 1 in 3.5

In the lower extremity 1 in 1.0

In fractures not implicating an articulation, upper extremity 1 in 3.

In ditto, lower extremity .. 1 in 1.2

Thirdly. In reference to favourable cases of fracture for treatment, large numbers, it is here shown, are required to determine the relative influence of external circumstances upon the mortality, since it is rarely heavy. The series brought forward only shows that the mortality in the upper extremity is not 1 in 16; in the lower, not 1 in 2, when treated under favourable circumstances. In the upper extremity it is not 1 in 17, and only 1 in 5.5 in the lower, when the circumstances are unfavourable.

Fourthly. Hence the ultimate conclusion at which we arrive is that, in reference to the mortality, the influence of external circumstances is greatest upon favourable and doubtful cases for treatment, and of site upon doubtful cases. Neither site nor external circumstances, nor any distinction in the nature of the injuries, when these are sufficiently grave to constitute a class of cases unfavourable for treatment, exercise any important influence on the mortality, inasmuch as all prove fatal.

An incurable injury of the forearm, if treated to the end without amputation, is likely to prove as fatal a case as any similar injury in the lower extremity. A badly plastered, useless, and painful limb, is the nearest approach to a successful result that can possibly follow; the great majority of patients will die under treatment.

These are the last results of the facts, and they inculcate the following

PRINCIPLE OF PRACTICE.

In favourable cases for treatment, the attempt to conduct them to a cure with the view of saving a useful limb, is always to be attempted wherever the injury be situate, whatever its description, or the nature of the external circumstances. In doubtful cases the nature of the external circumstances, and the *site* of the injury, when chances of cure and danger of failure are equal, as regards the *nature* and *extent* of the injury, decide the question: if situated above the knee, and the external circumstances are unfavourable, the balance is by those two conditions turned

against the patient; and if treatment be undertaken, it should be with this knowledge, and not at the recommendation of the surgeon, as calculated to save a useful limb. In cases unfavourable for treatment, wherever the injury be situate, and whatever be the condition of external circumstances, only one of two results are to be expected—the death of the patient, or the loss of the limb by subsequent disease or by amputation. The broken-down invalids who occasionally escape death, still retain a useless limb.

I have hitherto been speaking of the results of injury as regarded mortality alone, and in cases where amputation is not allowed to intervene in any stage, and the influence which the three principal conditions exercise upon it, and not upon the *nature of the diseased actions* supervening and proving the immediate *cause* of death; still less have I yet brought before you the conclusions arrived at in reference to the varying proportions of cases under the influence of such conditions requiring amputation, when the surgeon is willing to resort to it during the progress of treatment, and of those which allow no opportunity, and therefore perish.

This, however, is necessary, in order that the dangers attendant on treatment, and on amputations performed at three different periods in similar injuries and under similar circumstances, may be ultimately brought out and contrasted, and the principles of practice, in reference to the more complicated cases of injuries to the extremities, determined.

Nature of the Diseased Actions causing Death.

In reference to the diseased actions causing death in cases treated and not amputated, and the influence which the three conditions specified as affecting, in a remarkable degree, the mortality, may have upon the character of these actions, a very different result is obtained.

The *character* or *nature* of the supervening fatal actions are not materially affected by the degree or nature of the injury, its site, or the external circumstances under which the cases are treated, if we except that injuries of joints do not seem equally prone to induce secondary inflammations and purulent depôts in vital organs or distant parts.

The causes of death may, therefore, be taken on the whole series of 34 fatal cases of complete fracture, and 4 of partial fracture. Fever was the predominant diseased action in 21; 18 of defined character, viz., 10 hectic, 5 remittent; continued, intermittent, and irritative, 1 each; 5 were attended with secondary diseases of viscera, which probably, from the symptoms, existed in 4 more. In 2 of the 21, also, the limbs were gangrenous.

Seventeen deaths occurred by what I have termed "*accidental and irregular diseased actions*;" such as shock, tetanus, hæmorrhage, complicating wounds in other parts; 5 of this

number presenting, in addition, secondary inflammations of lungs or liver; 3 died in which the causes were unascertained.

The conclusion from these data, examined in great detail, let me recall to your memory—it was this. The mortality was caused in more than half the fatal cases, by actions leaving no trace of structural change or physical lesion, by deleterious impressions made upon the nervous centres, disordering the circulation, and deranging the vital functions. In the remainder of the fatal cases, the same influences were sufficiently manifest, although in a less striking manner, since they were accompanied with lesions of structure, local and organic, chiefly secondary diseases involving distant parts, and often important organs, in suppurative and inflammatory actions, sufficient to account for the death of the patient.

In any series of cases, submitted to treatment in the first instance, (but amputations performed during the progress of the case, whenever the supervening diseased actions, local or general, indicate the hopelessness of any further attempt to save a limb, the condi-

tion of the patient still allowing such an alternative,) the proportion of amputations required; and of the cases which terminate fatally among those remaining under treatment, it will be found, is not less strikingly changed, according as the cases fall under one or other of the leading conditions, the influence of which has been already shown, in reference to the mortality of cases submitted, from the beginning to the end, to palliative or curative treatment.

The proportion of deaths to amputations caused by the supervening actions in 137 (the number comprised in the series of *complete* fractures, and exclusive of partial fractures and of injuries to joints, only secondarily and indirectly implicated), is as 1 in 3.7 to 1 in 4. The latter being the proportion of deaths in all the cases not amputated.

A source of fallacy exists in the average thus taken, however, not only because it varies in the two classes of injuries, but in the injuries of the upper and lower extremities, which are not in equal proportions; the results, therefore, require to be stated in the following manner:—

				Proportion.	No. of Amputations.	Proportion.	Deaths—not Amputated.	Proportion.	Proportion of combined unfavourable Results of Treatment.	
Class.	No.									
FRACTURES.....	93	Upper extremity.....	50	1.8	11	4.5	4	1 in 12.5	15	1 in 3.3
		Lower extremity.....	43	2.2	12	3.5	12	— 3.5	24	1 in 1.7
			93		23	4.0	16	— 4.3	39	1 in 2.3
FRACTURES WITH PRIMARY INJURIES TO JOINTS	44	Upper extremity.....	16	2.7	3	5.3	3	1 in 5.3	6	1 in 2.6
		Lower extremity.....	28	1.5	11	2.5	15	— 1.8	26	1 in 1.0
			44		14	3.1	18	— 2.4	32	1 in 1.3
	137		137		37	3.7	34	1 in 4.0	71	1 in 1.9

It will be perceived that the proportion of amputations in fractures, when of the upper extremity, is three times that of deaths; while in the lower extremity, the proportion of deaths and amputations are equal: but the upper compared with the lower, shows the amputations in the former are only 1 in 4.5, instead of 1 in 3.5; while the deaths in the upper are only 1 in 12.5 as compared with 1 in 3.5. The combined unfavourable results accruing from the treatment of fractures is just *doubled* in the lower extremity, *the amputations being somewhat fewer, but the deaths nearly quadrupled.*

The cases of injuries of joints, compared with each other and with the preceding class, show the combined unfavourable results in both upper and lower extremities to be considerably larger: this difference being in equal proportions, however, on both upper and lower, and caused principally by the

excess of deaths, compared to amputations Fewer amputations are performed in the upper extremity for joint injuries than for fractures, but the proportion of deaths is more than doubled. Nearly one-third more amputations, on the contrary, are performed in joint cases when of the lower extremity, and the proportion of deaths is only just doubled.

The variation or difference in the proportion of amputations in each of the two *classes* of injury is from one-third to one-fourth; the former being the proportion in fractures implicating joints.

The relative proportions between those required by the upper and lower extremity in each varies. In injuries of joints, a greater proportionate number is required in the lower extremity compared with the upper, than in the class of fractures only.

The variation in the proportion of deaths i

each of the two classes is greater than the aggregate difference in the amputations. The proportion in joint injuries being between one-half and one-third, that in fractures *one-fourth*: in the former, however, the cases present nearly double the proportion of lower extremities. Still the mortality, which is *more* than doubled in joint injuries of the upper extremity, is increased just double in the lower. The difference is not, therefore, very sensible; but the deaths decrease in proportion as the amputations increase.

These proportions you are prepared to find again vary with the favourable and unfavourable nature of the injury, and the external circumstances under which treated.

In reference to the external circumstances, amputations are in larger proportion under favourable circumstances, and *vice versa*; and as the *amputations decrease*, the *mortality* in the cases treated *augments*. Thus, under different circumstances, amputation and death change their relative proportions; the one occupying, as it were, the other's place. But while unfavourable circumstances only diminish the number of *amputations* as much as *one-half*, the *deaths* become nearly *quadrupled* in the remainder of the series treated.

You have already had before you the altered proportions of amputations under the combined conditions of favourable nature of injury and of circumstances. Let me repeat it.

Fractures not involving Joints.

	Proportion of Amputa- tions.	Proportion of Deaths.
In favourable cases treated under favourable cir- cumstances	1 in 4	in 18 0
Ditto under unfavourable circumstances	1 in 1.7	1 in 16.
Doubtful cases under fa- vourable circumstances	1 in 1.4	in 4 0
Ditto unfavourable	1 in 2.	1 in 3.
Unfavourable cases under favourable circum- stances	1 in 2.8	1 in 1.0
Ditto unfavourable cir- cumstances	1 in 6.2	1 in 1.

Thus amputations are most numerous in doubtful cases treated under favourable circumstances; next in favourable cases treated under unfavourable circumstances; thirdly, in doubtful cases under unfavourable circumstances. Although one-fourth of the favourable cases treated under favourable circumstances seems a very large proportion, it will cease to appear so when it is recollected that no primary amputations were performed in this class, and no death occurred among those not amputated; thus one-fourth expresses the combined unfavourable result.

The deaths are most numerous in proportion to the number of amputations in unfavourable cases; whatever the nature of the

circumstances, all the cases were fatal. Doubtful cases, under unfavourable circumstances, stand next in proportion: lastly, favourable cases under unfavourable circumstances. In the class of doubtful and favourable cases remaining for treatment under favourable circumstances, there were no deaths. On these facts were founded the three conclusions:—

1. That when circumstances are favourable for treatment, and the cases, from their nature, offer a fair chance of recovery, although a fourth may require amputation by the development of morbid actions, few or none will die under the treatment adopted, with a view to save the limb. Even in doubtful cases, although a large proportion, say one-half, may require amputation, yet few or none will die under the previous treatment if carefully watched, and amputation be not deferred too long. But in the treatment of unfavourable cases under the best circumstances, not a third will allow of amputation after the first period has passed, and all not amputated will perish. A portion of those operated upon who recover will be nearly the only ones saved.

2. When the circumstances under which the treatment must be conducted are unfavourable, the number of amputations in doubtful and unfavourable cases for which there is opportunity, with a fair chance of success, is much diminished; and the number of deaths is increased in proportion. In favourable cases the number of amputations is, on the contrary, largely increased, and the deaths in a lesser degree. The opportunities for amputation are most rare in unfavourable cases under unfavourable circumstances. On the deaths which take place in all not amputated in this class, external circumstances have no control, at least in so far as the *result* is concerned, although they possibly, in some degree, modify and control the character and duration of the supervening diseased actions.

3. From these general facts the last conclusion may be drawn, viz., that in favourable and even in doubtful cases, judicious treatment, if it will not always save the limb, at least need not cost the patient his life (unless in exceptional cases), if good judgment be exercised in stopping the curative treatment, and resorting to amputation at the proper period. Thus, in doubtful cases, much may be adventured, in the first instance, to save a useful limb. In unfavourable cases, on the contrary, amputation or death, sooner or later, are the only results that can be anticipated; and the only object and legitimate end of any treatment is to save the patient's life, until a proper or favourable period may be selected for operation.

The Nature of Diseased Actions causing Amputation.

A comparison of the causes producing

death during treatment, and the supervening diseased actions necessitating amputation in order to save life, show the difference to consist chiefly in the large predominance of fever, of distinct types, among the causes of death. In thirty-eight, nearly one-half died with fever of defined type. In the amputations, although febrile action in many was present, no fever of a very defined character was fairly established, except hectic, in some of the secondary operations.

Again, some causes produce death which do not appear among the causes leading to amputation; such, for instance, as shock, complicating wounds, secondary inflammations, purulent depôts, &c.

Some actions there are which necessitate or lead to amputation, but are never causes of death; as, for instance, contracted and useless limbs, paralysis from local injury, pain and nervous irritation from lodgment of a foreign body, &c.

If we compare causes of amputation in joint injuries, and in cases of compound fracture, without such complication, the cases of secondary hæmorrhage and tetanus necessitating amputation occur exclusively in *fractures* and not in *joint cases*.

In the causes of death between these two classes of injury, we have seen that there are distinctions equally obvious; in fractures not involving joints only one-third of the deaths were from "irregular" and accidental complications, and two-thirds febrile: in joint injuries, on the contrary, more than one-half the deaths were caused by the class of "irregular" actions, the rest febrile.

In reference to periods of amputation, whether in the intermediate or secondary period, certain differences may be observed. Tetanus in the series before us was never developed in the secondary period, although thrice in the intermediary. Gangrene preponderates in the secondary period. Those causes of specific character which may be classed among the irregular or accidental, are presented as causes of amputation in the secondary more frequently than in the intermediary period; in the latter they amount to one-third, in the former to more than one-half. We shall shortly see that a still stronger difference exists between the causes of *death* in the amputations performed at these two periods.

It only remains to be shown how these diseased actions, supervening on fractures, treated and leading to amputation or to death, vary according to the favourable or unfavourable nature of the injuries for treatment, and of the external circumstances.

In favourable cases the majority of amputations are performed in consequence of the supervention of certain well-defined and specific causes, such as may with propriety be classed among the irregular and accidental causes: secondary hæmorrhage, sloughing, contraction of limb, periosteal disease, &c.

In doubtful cases a large proportion of the amputations have a similar cause; not far from one-half, however, are amputated for general and local deterioration, marked by no very distinctive characters, but clearly indicating the hopelessness of further efforts to save the limb, and this is the chief difference observable.

In unfavourable cases seven-eighths are amputated from the hopelessness of conferring benefit by treatment, and not from any specific or peculiar action, sloughing and secondary hæmorrhage appear alone as specific causes.

From these facts I pointed out, as a legitimate inference, that when *favourable* cases are selected for treatment, only such of them will require amputation as may become the subject of some accidental complicating diseased actions; but in *doubtful* cases nearly one-half may be expected to require operation, as the natural result of the inflammatory and suppurative processes usually set up. When *unfavourable* cases, by adverse circumstances, or error of judgment, are submitted to treatment, seven-eighths of the whole, if so many afforded opportunity, would require amputation from the evident hopelessness of cure, and the consequent and natural progress of all the actions, local and general, from bad to worse, and all with rare exceptions not amputated, die. There are fewer specific causes of amputation in this class than in any other. In a series of 23, only three cases occur—secondary hæmorrhage and sloughing being the diseased actions.

Comparing these causes of amputation with the causes of death in each of these classes, we find that in the *series of fractures* (exclusive of joint injuries) 55 favourable cases only gave rise to two deaths: one with bilio-remittent fever and secondary abscesses of lungs and liver; the second with febrile action, type not ascertained.

One patient died in 24 doubtful cases during treatment, from effusion in the chest and vomicae in the lungs.

Thirteen unfavourable cases were treated to the end, and all died—5 by hectic, with attendant bad actions; 1 bilio-remittent; 2 type uncertain; 1 secondary hæmorrhage and ensuing gangrene; 2 by shock; 1 complicating wounds and purulent depôt; 1 cause unknown at the end of three years.

As to the influence of external circumstances upon the diseased actions causing amputations, as in reference to deaths, we find the elements are the same in all—some difference existing in the proportion of one kind of diseased action to another. Mortification and sloughing—low action or excessive local disease predominate in cases treated under unfavourable circumstances, and indicate the kind of influence chiefly exercised on the nature of the supervening actions. The comparative frequency of the necessity for amputation, and the proportionate mor-

tality in cases not amputated, constitute the most important of the effects.

When the causes of death were compared with the causes of amputation, *both in reference to the site of injury*, as regards the upper and lower extremity, we found that more than one-third of the amputations of the lower extremity are performed to anticipate the full development of actions, the fatal consequences of which could not be doubted. In one instance only was this done in the forearm and hand, indicating that much more may be adventured in injuries of the latter during the first periods. Secondary hæmorrhage, however, preponderates in the forearm, wrist, and hand, as three to one. Sloughing and gangrenous action appear in both, but mortification of the extremity of the member in the lower extremity only. A sloughing action was developed in three of the upper extremity. Specific causes preponderate in fracture not involving joints, more than in injuries of joints, both in the upper and lower extremity. If we turn to the *causes of death*, considered in reference to the *site*, although we have only seven of the upper extremity, yet these present examples of many of the principal forms of disease which carry off those whose injuries are in the lower, viz., *shock, hectic, and exhaustion, with complicated wounds and sloughs, bilio remittent fever, and purulent depôts*. These few cases, however, do not give, as do the lower extremity, any cases of trismus, secondary hæmorrhage, delirium tremens, and gangrene of limb.

Larger numbers, especially of the upper extremity, are required, before we can safely determine that cases of the upper are really more exempt from these grave diseased actions than are those of the lower extremity.

We have thus determined, first, the predominating actions developed by chronic and local disease of limb; and secondly, by those supervening on the injuries of civil and military life, through almost every phase of condition and circumstance. These actions constitute the effects of such injuries, and lead when grave to one of two disastrous results—amputation or death, in proportions which we have again seen alternate with each other, according to the nature of the injury and the external circumstances under which the cases are treated.

With these conclusions, determining the effects of those local diseases and injuries of the extremities, which form the classes requiring amputation, we are prepared to understand and appreciate the effects of the operation singly, and when superadded to these states; and, finally, to determine by comparison, the advantages and disadvantages of amputation when adopted in such cases. This forms the proper subject of the SECOND PART of the summary, the details of which are comprised in the last nine lectures of the series.

PART II.

EFFECTS OF AMPUTATION performed on a limb free from disease and a person in health. Effects of amputation performed upon a patient long suffering from chronic local disease. Effects of amputation superadded to the shock of a violent injury, causing fracture of bone and laceration of soft parts. How modified by nature of injury, especially by the different characters of those occurring from the accidents of civil life and from the casualties of the field. Effects of amputation for the injuries of civil life. Effects of the operation for gunshot injuries, in reference to the primary, intermediary, and secondary periods: to the external circumstances: dynamic influences: upper or lower extremity, mode of operation, &c. Predominant diseased actions, causing death in each of the three periods, compared with those producing the same result when similar injuries are treated without operation. Conclusions. Influence of modes of dressing and after-treatment upon the results of amputation.

BEFORE we can appreciate the effects of amputation when superadded to local disease, or to injuries involving the extremities, we must first be able to determine what are the effects of amputation simply, uncomplicated by any previously-existing disease or effects of injury.

Pure Effects of Amputation.

These effects are local and general. *Locally*—Some inflammation and swelling of stump, with a tendency to superficial sloughing in the cellular tissue, where the knife had divided; partial or imperfect adhesive action between the divided surfaces, and partial or more general suppurative action in the stump, occasionally in parts contiguous. *General*—Some febrile action, marked chiefly by acceleration of pulse, ending a day or two after a suppurative process is established in stump, generally extending from the fifth to the ninth day. By the tenth day, total cessation of all inflammatory or febrile action. Subsequently, a depôt of matter occasionally forms about the stump, or above it, requiring an exit to be made, but not obviously affecting the system. These effects vary in degree: in one case a marked tendency to diarrhoea quickly supervened, betokening, probably, the influence of shock and the nervous system upon the mucous surfaces. The local inflammation and fever, instead of being slight, and only of a few days' duration, may assume a more alarming form, affecting the stump and all the organic functions, including the sensorium or cerebral centre, attended by perspirations and rigors, foul tongue, arrested secretions of skin and bowels, and either an ineffective suppurative action of stump, or a total absence of all effort. If suppuration during this struggle is developed freely in the stump, there is

general improvement, temporary or permanent; if temporary, the suppuration is arrested; sympathetic pains of abdomen; alternate excitement and prostration follow; leading, finally, to a state of coma, to relaxation of the sphincters, and death. A more or less diseased state of stump is generally found to have existed, and occasionally phlebitis. The result forms the corollary to the antecedent conclusion given in a former lecture, viz., that *pain* will effect a deleterious impression upon the nervous centres, disturb the vital functions, and destroy life, *without organic disease, or time for its development.*

Amputation thus produces, as the simple and unmixed effects of the operation, general and local inflammatory action, apparently induced, or at least accompanied by a more or less powerful impression upon the nervous centres; and the usual means adopted by nature for the relief of the system and cessation of this action is, by establishing the process of suppuration from the whole or a part of the surface of the stump.

We pass on to determine the effects upon the system of amputation, superadded to long pre-existing local disease of the extremity amputated.

The only records to which I have been able to refer you on this head, have been those of the amputations of the hospitals of Massachusetts and Pennsylvania, and more lately one from the Glasgow Infirmary. The former only furnishes the mortality, the latter gives some partial information as to the diseased actions causing death.

Effects of Amputation in Cases of Chronic Local Disease.

We found the mortality, in the two American hospitals, to be, in 48 of the lower extremities, 1 in 6; in 10 of the upper, no deaths.

At the Glasgow Infirmary, in 127 of the lower extremity, the mortality was 1 in 4; in 23 of the upper, nearly 1 in 6.

The mortality is considerably greater in the Glasgow Infirmary, which Dr. Lawrie attributes, and probably with much reason, to the pseudo-improvements of late years in surgery, by which we are led to believe cases curable long after they have ceased to be so; and defer having recourse to amputation, until obvious signs of dissolution threaten, at no remote period, to remove the patient, who is thus sacrificed to a vain effort to save a limb which does not admit of cure.

In both series the proportion of lower extremities amputated was quintuple that of the upper; showing the greater prevalence of disease in the lower extremity, and especially of the leg.

In reference to the CAUSES OF DEATH, the diseased actions are stated only in 17; 14 of these died from secondary inflammation, and 7 of the latter number with purulent depôts; 1 from cerebral effusion, and 2 from secondary hæmorrhage. Thus, if we take

the operations of the three civil hospitals combined, forming a gross total of 208 cases amputated for disease, of which 43 died, the proportion is 1 in 4.8. The average mortality is thus stated, as applying to unfavourable cases for treatment, under more or less favourable circumstances.

Upper extremity 33.. 4..1 in 8.2.

Lower ditto175..39..1 in 4.4.

The majority of deaths apparently occurring by secondary inflammations, showing more or less structural change. These are the results of the operation of amputation, superadded to a long-continued local disease.

Effects of Amputation performed for the Injuries of Civil Life, compared with the Results of Amputation for Gunshot Injuries.

In reference to injuries of civil and military life, the infliction of which must ever cause a shock somewhat analogous probably to that of amputation, we have traced the effects of the injury on the limb and the system, noted the differences between the effects of similar classes of injury in military and civil life, and under a great variety of conditions.

We have only now to retrace the effects of the double shock caused by the original injury and by amputation,—and the variations observable in proportion as the second shock of operation succeeds the first, occasioned by the injury, at a longer or shorter interval. How these effects again may be modified by varying conditions, in reference to the nature and degree of the wound, its site, the external circumstances, the dynamic influences under which the operation may be performed, and the subsequent treatment conducted.

The first classification, in reference to the nature of the injury adopted in these cases, was, into the injuries of civil life; such as are caused by the fall of stones, the passage of wheels of carts or carriages, and the accidents resulting from machinery, and those of military life, consisting chiefly of lacerations and fractures from musket, grape, and cannon-shot, or by explosions of gunpowder, shells, and rockets; more rarely by incised and bruised wounds from the sabre.

The necessity for this distinction does not appear at first very obvious, since in both military and civil life the more complicated injuries, of which I have above spoken, are alike compound, and more or less comminuted fractures, each usually attended with more or less bruising and laceration of soft parts, each liable to rupture of vessels, &c. But I have been led to believe, that there is a most important difference in the results obtained from the treatment of the two classes in the respective hospitals, due in great measure to a difference in the impression made by the original injury on the mind and nervous system of the sufferer. That the injuries of civil life and the amputations

for them, especially those performed in the primary period, are followed by more unfavourable results than equally grave injuries occurring in the field.

The returns of the civil and military hospitals, to which I referred you for data, confirm this opinion. If we reflect for a moment upon the mode in which the two classes of injuries are inflicted, I think an adequate reason will suggest itself. A man employed in some agricultural or manufacturing occupation, if he becomes the subject of a grave injury, it must be under circumstances for which his mind is totally unprepared, under circumstances the most calculated to cause terror and alarm, and a great shock, mental and physical. He is dashed down, trodden under horses' feet, and the wheels of the vehicle pass over him, or he falls from a scaffolding; the feeling, the instinctive dread of sudden death, must be strong upon him during these moments, few as they may be; and when he is extricated from his imminent peril, stunned, severely bruised, he awakens to consciousness to find that a limb is crushed, and his only chance of life is to submit to its removal by a dreadful operation: so of the accidents of machinery, what can be more frightful or more calculated to inflict an irrecoverable shock on the nervous system—a deleterious one, inevitably—than for a man to feel caught by a fly-wheel, whirled aloft, and his arm torn from his body?

In military life, the injuries inflicted are under very different circumstances; it is true, men but the moment before with sound limbs and in full health, fall with bones crushed and broken, with limb torn from their bodies. But every man goes into action knowing his liability to such occurrences; he sees his comrades fall on every side; many he sees bear it almost gaily—the majority with good courage; he has known hundreds to whom the same lot has fallen recover, and either return to their duty, or pass the rest of their lives not unhappily with a pension. He is excited at the moment; the onward rush, the shouts of the victors and the vanquished mingling with the roar of artillery, the flashing peals of musketry, all tend to make him reckless of any feeling, but one of wild excitement or enthusiasm. I have seen a man with his arm shot away cheering his comrades, unwilling to walk to the rear for medical aid until he saw the result of the charge; others have walked to me on the field, and requested me calmly to relieve them of the lacerated fragments of a limb torn away. The immediate shock of the injury is often, therefore, trifling in some of the worst injuries; and if a musket-ball strike him, he is often not conscious of what mischief it may have done. There are exceptions, particularly in regard to the injuries arising from shells and cannon-shot; but the general features marking

the *first effect* are thus widely distinct in the majority, where the extremities alone are involved.

The injuries of civil life received into the hospitals, on the other hand, possess this great advantage, that they are always treated under favourable circumstances in establishments provided with abundance of means at the surgeon's disposal. The only proper comparison that can be made, therefore, is between the results of gunshot injuries treated or amputated under favourable external circumstances.

In reference to those *treated without amputation*, you have seen that in military hospitals in eight doubtful and unfavourable cases of injuries to the upper extremity, treated under favourable circumstances, the mortality was 1 in 2.6. Two out of the three deaths being occasioned chiefly by complicating wounds of chest; the remainder of the six cases being injuries of joints, of which only one died. In nine of the lower extremity, nearly equally divided between fractures simply and those involving joints, the mortality was 1 in 2.2; the four deaths occurring exclusively in the joint injuries. The mortality then, where the upper and lower extremities were in nearly equal proportions, exclusive of two cases having fatal wounds of chest, was 1 in 3. Whereas, in Dr. Lawrie's return of forty cases treated for the complicated injuries of civil life, the mortality was 1 in 2.2, with scarcely a fractional variation between the proportion of deaths in the upper and lower extremities.

In reconsidering the *Effects of Amputation* in each class, we shall see this result confirmed, and the preceding observations fully borne out.

Mortality of Amputations in Civil Hospital.

In the two American hospitals, the primary amputations give a mortality in forty-three cases of the upper extremity of 1 in 5.6; in the lower, 1 in 3.2, Dr. Lawrie gives a much less favourable return of the Glasgow Infirmary; in forty-one of the upper extremity, the mortality is 1 in 3.1, and in the lower extremity it is 1 in 1.7. The mortality, therefore, is about doubled. In the upper extremity, the difference is in the arm; a proportion of one-third dying in America, and one-half at Glasgow. In the lower extremity, ten-elevenths died in the thigh, and nearly three-fourths in the leg, at Glasgow; whereas in America only about one-half of the thigh amputations were fatal, and *only 1 in 14 of the leg!* I call your attention more particularly to the last fact, because Dr. Lawrie is disposed, incorrectly I think, to consider the amputations of the leg more fatal than those of the thigh, as in the series before him, amputated for *disease* it proved to be, and he endeavours to account for it. By what combination of circumstances they were so fatal in the Glasgow Infirmary, it may be difficult

to say; but that they are not habitually or usually more fatal, quoad the *amputation*, is a fact placed, I should say, beyond doubt. I confess it seems to me, that no case is made out why the operation "below the knee" should be abandoned; while all the reasons which have induced surgeons to leave no superfluous length of limb, remain untouched.

Mortality of Amputations in Military Hospitals.

In a series of primary amputations for injuries of the field recorded by Mr. Guthrie from the battle of Thoulouse, and another series recorded in the hospitals under my charge, both series treated under fairly favourable circumstances, the mortality in the upper extremity you have seen was 1 in 9.5; in the lower, 1 in 4.7: which, compared with the most favourable results in civil hospitals before us, gives a proportionate success not far from double that obtained by amputations for the injuries accruing from railroads, machinery, &c. And if we take the average of the least successful, those of the Glasgow Infirmary, the mortality in the primary amputations of the military hospitals is two-thirds less in both the upper and lower extremity.

Thus, in reference to the injuries of civil and military life, it is evident that the mortality of primary amputation for the former is at least doubled; and sometimes the deaths exceed those resulting in military life by two-thirds. There must be a cause for a difference as constant as it is great.

The same result, however, does not hold good in the cases usually clubbed together as *Secondary amputations*, that is to say, all those performed after the primary period.

In the American civil hospitals, the mortality is 1 in 11 in the upper extremity; 1 in 2.2 in the lower. In the military hospitals before specified, in the upper it is 1 in 4.6, in the lower 1 in 2.

Mark the conclusion, the primary amputations for injuries of military life, which, compared with those of civil life, presented a mortality less by one-half; in secondary amputations give the reversed conclusion of being twice as fatal in the upper extremity, and a fraction more fatal in the lower. Take even the Glasgow Infirmary, which gave the least favourable view of the results of amputation for the injuries of civil life; the secondary amputations give a mortality in the upper extremity of 1 in 2.4, and of 1 in 1.5 in the lower; and we find that, although still presenting collectively a greater mortality than the military hospitals, the disproportion is much diminished; and, compared with the results of the primary amputations in that institution, you will find that the secondary amputations of the thigh and leg are much more successful—in a striking degree, instead of ten-elevenths and three-fourths dying, the mortality is two-thirds, and in the leg a

trifle less. There is but little change in the upper extremity.

The results of amputations in civil hospitals for chronic local disease, where there is only one shock sustained, although the limb be much diseased, gives a much smaller mortality than either *primary* or *secondary*.

If we take the civil hospitals altogether, there can be no doubt that the relative success stands thus: 1. Amputations for chronic local disease. 2. Secondary amputations for injury. 3. Primary amputations.

This order can only be reversed and brought *partially* to that established by the army surgeons by reference to military hospitals, containing a class of injuries which, however analogous in some points, present to the philosophic inquirer very important differences, calculated to exercise, as they are thus demonstrated to do, great influence on the results of amputation. Thus may it be proved that a one-sided view has alone been taken by civil surgeons, with John Hunter at their head, in 1790, and by army surgeons who closed the record of results some twenty-five years later, including Messrs. Larrey and Guthrie as the two principal recorders. Of the two advocates, John Hunter approached nearer the truth; for he adopted a correct principle in stating that a man was not in a state the nearest approaching to health a few hours after receiving a severe shock from an injury, and that he may be in a more favourable state for an amputation and its second shock at a subsequent period; whereas in trying to reconcile facts to a theory—a labour the military surgeons undertook—they upheld a doctrine which I believe to be untenable, and, applying the experience of the field to civil hospitals, they fixed a practice upon civil surgeons in opposition to *their* facts and daily experience, from the trammels of which they have never made the effort necessary to release themselves. A large and comprehensive series of observations would soon have demonstrated *error* somewhere in the principles of the army surgeons, when applied to the treatment of the injuries of civil life, leaving the *experience* and the *facts* of the army surgeons untouched (as applying to military life), yet showing them inapplicable to civil practice.

Let us include the results of military hospitals. You will find, then, indeed, the order of the military surgeons in part re-established. But the results of civil hospitals reverse all their theories as to the state in which the patient bears best the shock of an operation. In them the first rank is unavoidably assigned to amputations performed on subjects *far from a state of rude health*. This they maintain to exist immediately after the violent shock of an injury, and next declare it to be the *chief cause* of success in primary amputations on the field over all performed at subsequent periods.

The results of military and civil hospitals combined stand in the following order :—

First. Amputations for chronic local disease.

Second. Primary amputations for injuries of military life.

Third. Secondary amputations for injuries of civil life.

Fourth. Primary amputations for injuries of civil life.

Fifth. Secondary amputations for injuries of military life.

The question of primary and secondary amputation is here reversed in military and civil life. The main doctrine on which the army surgeons explained and upheld the superior excellence of primary amputation and its universal application (*viz.*, the rude health of the patient), is shaken to the centre by the most successful of all the series of cases, proving to be those performed where long pre-existing disease and often confinement has removed the patient far from a state of robust and plethoric health, to one of debility and emaciation.

Is it not strange that the medical practitioners of civil life, of large cities, whose talents are employed in large institutions, where hundreds of cases of amputation for injury and disease, in a few years must pass under their observation, should for so long a period have accepted doctrines and results, the first fallacious, and the latter inapplicable, and to which the facts and experience of their own practice are totally opposed?

Question of Primary and Secondary Amputation in Reference to the Injuries of Civil and Military Life decided by Results.

It is only within the last few years that any inquiry seems to have been awakened. Four years since I myself ventured to call in question the accuracy of those views which decided a primary period to be always the best for amputation, and the doctrine that it was so, because the patient was at such time in a state the nearest approaching to health. This doubt had been long suggested by the effects which I had observed, were developed in primary amputations for gunshot injuries, and without peculiar reference to the results in civil hospitals. But reference to the results of amputation in civil hospitals more than suffice to confirm those doubts.

Within the last few years, independent of the records of the two American hospitals and of the Glasgow Infirmary, various results have been published, calling the attention of the profession to facts opposed to the prevailing doctrines on amputation.

M. Gendrin, in 1835, gave, in a thesis, the result of sixty amputations performed in Paris, in which they took the following order as to success :—

First. Chronic disease.

Second. Secondary amputations.

Third. Primary.

And although the mortality was excessive in all, still thus they stand.

In 20 amputations performed on children for chronic diseases in 1834, all recovered.

In reference, then, to amputation, what are the first conclusions to which these facts lead? The details have been stated and analysed, and when laid before you, the inferences from each were deduced. In their most condensed form they are these :—

Conclusions on the Relative Advantages of Primary and Secondary Amputation for the Injuries of Civil and of Military Life.

First. Between the injuries usually received into civil hospitals of a nature to require amputation, and those occasioned by the casualties of the field, an essential difference exists, exercising a most important influence upon the progress of the case and the results of amputation.

Second. This difference consists chiefly in the greater shock, moral and physical, generally caused by the *infliction of the injury* in civil life, from which the patient does not sufficiently recover in the first twenty-four hours to bear the second shock of an amputation; hence is this first period less favourable for the operation, than one more remote, when the alarm has ceased, the febrile action had time to develop, and to be finally relieved by the suppurative process.

Third. In proportion as this first shock or alarm is great in the injuries of military life, are the results produced the same. Hence amputations for wounds from cannon-shot and shells more nearly approach in their effects to the injuries of civil life. It follows that it may often happen in military practice, that the system is not seriously implicated within the first few hours, and amputation may be advantageously performed; while in those of civil life, amputation within twenty-four hours adds a second violent shock to the nervous system generally, while the patient is still under a strong deleterious action from the first; and the result is either death by shock, or by the development of violent febrile action, by phlebitis, secondary inflammations, tetanus, gangrene, &c.

Fourth. Extensive experience proves that where a violent commotion has been sustained, deeply involving the nervous centres and the *morale* of the patient, the operation is better borne after the suppurative process is established. In gunshot injuries, however, where the whole of the structures of a limb are involved by the lacerating course of the ball and the excessive comminution of bone, added to the jar or shock communicated by the crushing force of the ball in contact, a more fatal and extensive action is developed, leading to greater irritation and exhaustion in the system than the ordinary injuries of civil life: thus operation in a subsequent period proves less successful than when performed in civil hospitals.

Fifth. The result of amputations performed for long existing disease of a limb, often after exhausting suppuration has been long continued, the patient emaciated and greatly debilitated, prove incontrovertibly that this is not an unfavourable state for the success of amputation, the supervening actions are generally less fatal in character, less violent in their development.

These conclusions indicate the principles of practice in reference to the casualties of civil and military life, and are strongly supported by all the facts which the preceding lectures have brought under your notice.

Influence of Modifying Circumstances on the Results of Amputation performed for Gunshot Injuries.

We have yet to trace the influence exercised on the results of amputations by such variations in the nature of the injury as prevail in the casualties of military life, such for instance as the period at which the operation is performed, the site, the external and dynamic conditions attending the operation, the subsequent treatment, and, finally, the mode of operation, after dressing and treatment. Those influences will be judged by two orders of effects: first, the proportionate mortality; and, secondly, the nature and course of the diseased actions, which are the immediate cause of a fatal result.

The classes under which we may best consider the variations in the nature of injuries as regard amputation, are the same as those adopted in considering the same injuries under treatment. Injuries of joints—injuries only fracturing the shafts—injuries favourable, doubtful, or unfavourable, in reference to their fitness for treatment and cure. These have to be considered in reference to periods of amputation, which are three; the *primary*, before the supervention of febrile action; the *intermediary*, from its supervention to its abatement or cessation usually marked by the full development of suppurative action; and *secondary*, any subsequent period before the healing of the wounds. Let me recall to you the chief characteristics of the progress and results of operations performed in each of these periods.

Primary [Mortality] Amputations,

In military life, we have seen, are the most

successful. The series I selected for analysis consisted of 57 cases performed in the hospitals under my charge, the majority in the same locality in twelve consecutive months; of these, 29, or more than one-half, died. Thus you saw that even primary amputations for gunshot injuries are liable to modifications in their success, even if you had not seen that in one series of 18, 15 died. The same causes which influence the primary, may probably modify the results of amputations performed in the intermediary and secondary periods. In reference to external circumstances and dynamic influences prevailing during the treatment of amputations, I stated that I had always observed that, when these were highly unfavourable, the consequences seemed to fall more heavily on the primary than the secondary, not only reducing the favourable balance, but occasionally giving the advantage to the secondary, while the intermediate amputations all perished. Under favourable circumstances, on the contrary, the order in rates of mortality beginning with the most successful, is, first, primary; secondly, secondary; thirdly, intermediary.

Thus, in proportion as the circumstances are favourable, is the preponderance of success in primary over all subsequent amputations; but, as those circumstances become highly unfavourable, the preponderance diminishes, until at last the secondary become the least fatal; the order is, then, secondary least, primary next, intermediary all fatal.

An obvious difference, however, is observable between the effects of unfavourable circumstances, when these are external and physical, and when they are of dynamic character affecting the morale of the patient. Of 36 amputations, under more or less unfavourable circumstances, 18 were performed under distressing and highly-deleterious dynamic influences. To ascertain, therefore, how far physical circumstances influence the result, when there is no other unfavourable influence predominating, I separated the 18, and considered the mortality and diseased actions supervening on the remaining 18, of which number 10 died. The different mortality of 15 in 18 and 10 in 18 alone indicating an influence in the one, not existing in the other. In 21 primary amputations performed on the field and in hospital under favourable circumstances, 4 died, or 1 in 5.

Primary Amputations.

		No. of Cases.	Deaths.	Proportion.
Under favourable circumstances 21 (9 of the thigh)	{ Upper extremity..	11	1	11.
	{ Lower ditto ..	10	3	3.3
Under more or less unfavourable ditto 36	{ Upper extremity..	21	13	1.6
	{ Lower ditto ..	15	12	1.2
		57	29	1.3

But if we analyse further, 18 were under deleterious dynamic influences 18	{ Upper extremity..	9	7	1.2
	{ Lower ditto ..	9	8	1.1
And 18 under unfavourable external influences only 18	{ Upper extremity..	12	6	2.
	{ Lower ditto ..	6	4	1.5

Thus merely external circumstances, when unfavourable, increase the mortality in the upper extremity more than five times; in the lower it doubles it. But when to temporary and but partially unfavourable external circumstances are added deleterious dynamic and moral conditions, the mortality averages, in the upper and lower extremity, from seven-ninths to eight-ninths of the whole number amputated. In each of the three conditions the more they are unfavourable the less difference is there between the relative mortality of upper and lower extremity. Thus, under Favourable conditions 10 in 11 are saved in the upper.

„ 1 in 3.3 in the lower.
Unfavourable physical.. 1 in 2 in the upper.
„ 2 in 3 in the lower.

Unfavourable dynamic in addition 1 in 4.5 in the upper.
„ 1 in 9 in the lower.

Thus much for the mortality under varying external and dynamic influences, and in reference to site.

Nature of Diseased Actions causing Mortality.

We found their nature changed also in different circumstances.

In the 29 fatal cases in 57 primary amputations—

4 occurred under favourable circumstances.

10 under unfavourable physical and collateral circumstances.

15 under partially unfavourable physical, but predominating unfavourable dynamic influences.

The diseased actions in the 4—

- 1 irritative fever; no organic disease.
- 1 bilio-remittent; phlebitis.
- 1 phlebitis and purulent depôt in a joint.
- 1 necrosis and vomicæ of lungs, &c.

In 10—

- 3 irritative fever.
- 2 cholera.
- 1 tetanus.
- 1 hectic.
- 1 bilio-remittent.
- 2 febrile type not ascertained.

—

10

In 15—

- 10 bilio-remittent; 5 arm, 5 thigh.
- 9 with diseases implicating viscera;
- 4 of thigh.
- 1 abscess of thigh.
- Disease of lungs and liver in 4; of lungs only, 4; of liver only, 1; phlebitis (arm), 1.
- 2 irritative fever; phlebitis in both, abscesses of lungs in 1.
- 1 hectic, phlebitis.
- 1 type doubtful; abscesses in lungs, liver, and shoulder-joint.
- 1 shock of operation.

—

15

The chief difference to be observed when dynamic influences of unfavourable character prevail, therefore, is the large preponderance of bilio-remittent type of fever; of purulent depôts in distant parts and in the viscera; finally of phlebitis. These occur in each of the other conditions, but in different proportions. These latter fatal actions occur in pretty equal proportions in upper and lower extremities. If we look, therefore, at the causes of death in the whole 57 primary amputations, the chief actions in 29 fatal cases run in the following numbers:—

13 bilio-remittent; all (except one not examined) with secondary diseases of viscera, or with purulent depôts in the limbs.

5 irritative fever, 3 in like manner complicated, and 2 with phlebitis.

2 hectic fever, 1 with phlebitis.

1 purulent depôts of lungs and liver, with no distinct febrile type.

1 phlebitis, ditto.

2 cholera.

1 shock of operation.

1 tetanus.

3 causes not clearly ascertained.

—

29

Compared with the causes of death in 38 cases not amputated, we have the effects of one shock in the injuries treated; and the diseased actions resulting from two, quickly succeeding each other in the primary amputations. The actual proportion of the febrile and the irregular actions is not very different, but the remittent is predominant in amputation; the hectic in cases dying under treatment. The proportion of irritative fever in primary amputations is about that of the remittent in fractures. The proportion of tetanus and shock is more than doubled in cases treated.

As to proportion of secondary inflammations, abscesses, &c., in 21 febrile cases in fractures treated, they were proved or suspected in 9—nearly *one-half*. In primary amputations in 20, 15, or three-fourths. In 14 fatal cases from irregular action during treatment for the injury, 5, or nearly one-third, were ascertained; after primary amputations in 9, 2, between one-fourth and one-fifth. Combined, the number of secondary inflammation and depôts, 14 in fractures, 17 in amputations, shows a proportionate difference of 1 in 2.5 to 1 in 1.7. Phlebitis, of frequent occurrence in primary amputations, is rarely met in injuries treated. Secondary hæmorrhage, shock, tetanus, gangrene—some either do not appear at all in the causes of death in primary amputations, or in much smaller proportion than in cases treated.

Thus it is evident that while primary amputations are less endangered by the four above-mentioned irregular actions than cases treated, they are infinitely more obnoxious to the worst form of fever and the worst

complications, viz., secondary inflammation, purulent depôts, and phlebitis. And while more than half the cases of injury treated perish, without trace of organic disease or lesion of any important viscus, scarcely one-sixth die after primary amputation, without leaving trace of structural change in the viscera or venous system.

The conclusion arrived at from a consideration of the two sets of unfavourable cases of primary amputation, is, that there are two classes of causes materially influencing the development and character of diseased actions supervening on primary amputation, and consequently on the mortality of such operations—the one moral and dynamic, the most fatal and difficult to combat, and the most subtle in its characters. The second are physical, and generally sufficiently obvious. Under the first of these, bilio-remittent fevers, purulent depôts, and secondary inflammation, are at once the most frequent and fatal consequences; and the mere physical and external conditions under which primary amputation is performed, and subsequently treated, exercise little or no direct influence upon the development of the peculiar class of diseased actions, which are probably dependent upon a dynamic order of causes, acting chiefly through the nervous system. The same effects, but in smaller number, are observed, under such circumstances, to supervene on the same injuries treated without amputation.

Primary amputation, performed under unfavourable circumstances, is an operation under which the system becomes highly susceptible of supervening actions fatal to life, and its susceptibility, as well as the deleterious nature of the actions, seems to be in relation to the violence of the shock communicated either by the injury or the quickly succeeding shock of the operation. Thus precisely the same results may follow the one or the other, whether occurring in the upper or the lower extremity.

If the shock be really severe, therefore, it is sufficiently demonstrated by the primary amputations in civil life, that the body is not in the best state for its successful issue; and that as a state of chronic local disease seems by no means to place the patient in an unfavourable state for the single shock of an operation, it is easy to understand how cases selected from those patients who, after an injury, survive beyond the inflammatory stage, without serious organic disease, with a local disease as the chief result of the first shock, do actually present a more favourable condition for the success of amputation, than within the first twenty-four hours of the infliction of a violent shock.

Conclusions in reference to Amputation performed in Intermediary and Secondary Periods. Mortality and Nature of Diseased Actions.

In 27 amputations in the intermediary period, 17 died.

		Mortality.
13 upper extremity ..died 8....	1 in 1.4	
14 lower ditto	9.... 1 in 1.5	
—	—	
27	17.... 1 in 1.5	

Tolerably equally divided, both as regards circumstances for treatment and numbers of each extremity.

7 died from irritative fever; 4 bilio-remittent; 3 fever, less defined; 3 trismus.

Secondary hæmorrhage occurred in 1; phlebitis in 3; secondary inflammations or purulent depôts in 5; tetanus in 3. The proportion of these complicating actions was 1 in 1.58.

In 25 secondary amputations—

Upper extremity ...	8....	1....	1 in 8.
Lower ditto.....	17....	8....	1 in 2.1
	—	—	—
	25	9	1 in 2.7

5 died of shock, or nearly one-half, aided in 3 by secondary hæmorrhage; sloughing of stump, and hectic.

1 exhausted; 1 hectic and diarrhoea; 1 erysipelas; 1 irritative fever, with secondary hæmorrhage.

Secondary hæmorrhage occurred in 2; phlebitis in *none*.

Secondary inflammation and abscesses in *none*; tetanus in *none*.

Shock in 1 in 3.5 was the leading cause superadded to a low hectic fever.

The complicating actions, therefore, were in larger proportion than in any other class; yet three of the most fatal actions are not present.

Drawing our conclusions from 93 deaths occurring, constituting the four classes of cases, viz.:

38 fatal cases of injuries treated without amputation.

29 fatal cases of primary amputation.

17 fatal cases of intermediary amputation.

9 fatal cases of secondary amputation.

—
93

Comparative Results in reference to leading Causes of Mortality.

We found that the primary amputations were more obnoxious to secondary inflammations and depôts, and visceral disease, than intermediary; while the liability of the latter to phlebitis was about equal. That fractures are less liable than either to the purulent depôts, diseases of viscera, &c.; and no case of phlebitis was traced in the whole series of 38 deaths occurring among the injuries treated and not amputated. Lastly, that if secondary amputations were not exempt from three of the most fatal of the whole range of the supervening actions, viz., phlebitis, secondary inflammations of viscera and purulent depôts, and tetanus, they were at least by no means equally liable.

Hectic supervenes, and is occasionally fatal in three of the classes; it is in equal proportion in the injuries treated to the end, and

secondary amputation—more than 1 in 4 died from its effects, while it does not appear in intermediary amputations.

Irritative fever is common to all—almost the only action of which this can be said, but its proportions vary. It is least prevalent in cases treated, 1 in 15; in secondary next, 1 in 9; it is in largest proportion in intermediary.

Secondary hæmorrhage occurs in all, most frequently in secondary amputations, 1 in 4.5.

Tetanus is most frequent in intermediary amputations, 1 in 5.6; next in fractures treated, 1 in 6.5; in primary amputations, only 1 in 29.

Shock, or that impression on the system from which the patient evidently never completely rallies, is a fatal effect in all, carrying off one-half of the secondary amputations when the operation is performed in an exhausted and hectic state. In injuries treated it is 1 in 12, and only 1 in 29 in the series of primary amputations. The proportion of those who die by the immediate and palpable effect of shock, I have already remarked to you, is not large, except in the worst kinds of cannon-shot injuries, or with many complicating wounds. But the number who die of its less obvious or sudden, but not less certain effects, is in a much larger proportion than these figures convey, which only refer to the patients who die within twenty-four or forty-eight hours.

In reference to the intensity of actions, as shown by the average duration of life after operation, the average term of death in intermediary amputations is 14 days; in secondary, seven days; yet the most destructive actions prevail in the intermediary, with the single exception of shock. When cases of intermediary amputation terminate fatally, they do so by vigorous attacks of febrile and inflammatory actions, as stoutly resisted in the first instance; the secondary sink, by the continuance of the enfeebling and exhausting actions which led to the operation only as a last resource; and when the powers of the system are too far gone to resist the shock of an operation, the patients sink, in a period varying from a few hours to six or seven days. In intermediary amputation the disease is more intense, but so is the frame stronger, and their fatal development requires an average term of from twelve to fourteen days.

If all amputations performed after the primary period be taken together, the average term for the fatal development of diseased actions supervening, is for the upper extremity fifteen days and a half, for the lower eight. The period lengthens as the injury becomes less severe; amputation for injury of the radius, ulna, and hand, give an average of nineteen days.

Excepting the prominent part, however, played by shock and by secondary hæmorrhage in the lower extremity, the actions do not differ in their nature, in this lies the

chief distinction: three-fourths of the lower extremity are carried off by actions of which shock forms a principal feature, while in the upper extremity death from shock is very rare.

On this part of our subject I only think it necessary to recall the chief and peculiar dangers of each of the four classes.

In complicated injuries of the extremities, for which amputation is not performed, the prevailing actions and causes of fatal result are,—

1. *Bilio-remittent fever*, with complications, chiefly purulent depôts, secondary, intermediary, &c., but *not* phlebitis.

2. *Hectic fever*, with its most usual complications, diarrhoea, sloughing, and unhealthy, local, suppurative, and disorganising actions.

3. *Irritative and continued fever*, with other forms, and attendant unfavourable local actions.

4. *Shock and tetanus*.

5. Secondary hæmorrhage, disorganised limbs, mortification, &c. Nos. 4 and 5 may be classed as accidental complications.

Thus these injuries under treatment are liable to the action of *all the causes* supervening on three classes of amputation save one—phlebitis; and liable, moreover, to actions from which secondary amputation in the series before us are exempt.

Primary amputations. — Bilio-remittent, with complications of purulent depôts, &c. (not phlebitis), largely predominates, most so under unfavourable dynamic influences, but it occurs in all sites and under all circumstances. *Irritative* fever, with similar complications, and phlebitis: these are the two leading causes of death. In nearly one-half, secondary inflammations, involving viscera, occur, and between one-fourth and one-fifth laboured under phlebitis.

Primary amputation, then, is liable to each of the causes of danger and death which are observed to supervene in all the classes under consideration, the most dangerous in the largest proportion.

Intermediary Amputations.

But little difference, you have seen, existed between the character of the supervening actions in intermediary and primary amputations. I have been led to believe that there is a greater proneness in *primary amputations to take on any diseased action which may be prevailing at the time*.

In *Secondary* amputations, shock with the prevailing hectic, and diarrhoea, are almost the only important supervening actions to be dreaded. These cases are infinitely less exposed to all the more fatal actions attending the other classes. If the patient escape the immediate effects of the shock, there is every reason to anticipate his total escape from the many other diseased actions of fatal charac-

ter supervening on injuries treated, and primary or intermediary amputations.

These are the conclusions arrived at by strict analysis and careful study of a large number of cases. To endeavour to recapitulate the conclusions, in reference to the *causes and progress* of the diseased actions I have enumerated, would carry me too far. The result I would enforce in reference to the principles of practice, is the necessity of determining the question of treatment or amputation at different periods, in reference not only to the nature of the wound, but to the shock experienced by the infliction of the injury. Wherever it has produced a violent commotion, as in the accidents of civil life; more rarely in gunshot wounds, primary amputation is full of peril. In military life, if external and dynamic influences be favourable, there can be no doubt that in the greater part of the worst cases, including cannon-shot, even when the shock has been great, if the patient rally at all effectively within the first twenty-four hours, a great saving of life will result from primary amputation in the upper extremity, and rarely less than two-thirds even of the lower, will be saved. It is not so after the great commotion, the terror and the shock, moral and physical, succeeding most of the graver accidents of civil life. The most favourable returns show a mortality of one-sixth in the upper, and one-third in the lower extremity; the least favourable is one-third in the upper, and two-thirds in the lower, $\frac{10}{11}$ ths of the thigh dying. These, compared with the secondary amputations of each institution, show a decided advantage in favour of the latter. Thus in civil life, even if we add to the mortality of secondary amputations, those deaths which occur in the intermediary period, there is still much reason to believe that the absolute mortality would be diminished, if no primary amputations were performed.

In military practice, on the contrary, the whole of the facts tend to prove the superior advantage of primary amputation, except under one condition, viz., under temporarily unfavourable physical circumstances; when to these are added *deleterious dynamic influences*, and where the morale is depressed and unfavourably acted upon. The result of the March series, where only three cases were saved out of eighteen, sufficiently proves, when compared with the results of those treated and not amputated in the same period, even allowing that the latter were among the most favourable cases, that a much greater amount of life would have been saved, had the operation been deferred to a secondary period.

Under unfavourable circumstances, the great advantage observed to belong to the results of amputation of the upper extremity, over the lower is nearly lost. The mortality falls nearly equally upon both.

Again, under unfavourable circumstances,

intermediary amputations no longer offer any hope of saving life: the few that are saved are always under favourable circumstances.

Decidedly unfavourable conditions and circumstances have in proportion less influence on the results of secondary amputation, than in either of the other classes. Thus, if the patient's strength be not utterly exhausted, so that there is every probability that the first shock will at once prove fatal, the operation often succeeds against all ordinary calculations, the actions destructive of life are very few (shock, hectic, secondary hæmorrhage); the latter occurring in one-fifth of the cases; and if the operation were performed as soon as the suppurative action is fully established, and the fever subsided, the numbers saved both in military and civil practice would be greater than is usually observed when treatment is generally too long persisted in.

Influence of Modes of Operation. Dressing and After-Treatment.

I devoted the last three lectures to the consideration of the influences due to different modes of operating, of dressing of the stump, and of after-treatment, testing the flap and circular modes by relative rates of mortality, and the proportion in which various unfavourable diseased actions supervened in each. The following conclusions resulted.

The mortality is somewhat less in operations by circular incision than by flap, in both in the upper and lower extremity, in favourable and unfavourable circumstances, primary and secondary.

Primary.

Mortality.

Lower Ex. Upper Ex.

Amputations by circular incision under favourable circumstances ..	1 in 3	1 in 7
Amputations by flap incision under favourable circumstances ..	1 in 2	1 in 4
Amputation by circular incision under unfavourable circumstances	1 in 1.2 ...	1 in 2
Amputation by flap incision under unfavourable circumstances ..	1 in 1.2 ...	1 in 1.7

Flap operations we found less liable to secondary hæmorrhage, particularly in the lower extremity and in secondary amputations; but in primary amputations, if the whole number be taken, the advantage would seem in favour of the circular incision. Under favourable circumstances the cases of secondary hæmorrhage in circular operations is doubled; under unfavourable, the flap has a larger proportion than the circular, but not in the upper extremity.

It would seem that the flap is more adapted for the lower extremity in favourable circumstances, and for the upper in

unfavourable; but these results want confirmation by the results of very large series.

No obvious influence was traced on exfoliation or tendency to conical stumps. In reference to period of healing we found the flap had the advantage, and in *secondary amputation* this advantage is considerable: in flap the average period was sixty days, in circular ninety. In the injuries of civil life, the circular operation exhibits a considerable advantage over both; but there are no flap operations to compare with these in the same institutions.

The most important of the results derived from this analysis of results the in two modes of operating, was the greater liability of flap operation to the supervention of phlebitis, secondary inflammations, and purulent depôts.

This coupled with the greater mortality, which is probably the effect, seems to more than counterbalance any of the advantages observed, and lead to the conclusion that the flap is only preferable in certain exceptional cases and conditions such as I indicated.

In reference to torsion and short-cut ligatures, they possess no advantages over the more usual mode, and some grave inconveniences are attached to their adoption.

One word more on the putting-up of stumps, and especially the delayed dressing; its *disadvantages are great and certain; its advantages at best doubtful.*

Union by first intention I showed you while it was not a safeguard to the supervision of the worst consequences, in bad actions, local and general, often exercised a most injurious influence upon the results favouring the development of inflammatory action, which nature invariably attempted to relieve by establishing a suppurative process in the stump.

The conclusion from such considerations is, that the indiscriminate endeavour in all cases and circumstances to obtain union by first intention, is condemned by the results as *injudicious, unscientific, and often highly prejudicial.* In reference to this subject, I defined three classes of cases authorising and requiring three different modes of dressing, as those best calculated to promote the success of the operation, in the anxious hope that a treatment, modified upon fixed principles in reference to the *nature of the cases*, will attract the serious attention of the profession, and ultimately meet with the favour but too often reserved only for extreme and sweeping measures, and a routine of treatment which, if fitted for one set of cases and circumstances, is totally inapplicable to others differently characterised.

I cannot conclude without expressing an earnest hope that the profession generally, and more especially hospital surgeons, whose opportunities in all countries are great, of making extended observations, and of collecting the most accurate records of a large number of cases, may be induced carefully to reconsider the grounds on which the prevailing doctrines, in reference to the treatment of complicated injuries of the extremities, and the expediency of amputation at different periods in civil and military life, are founded: that they will put them to the tests obtained by the analysis of the results of large numbers of cases. The united labours of hospital surgeons and others to thoroughly investigate the subject upon their accumulated records, would soon remove all inconsistency and contradiction between the doctrines and effects, and leave no room for further doubt as to the true principles of the most successful practice.

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